Chapter 2

Television Broadcasting

INTRODUCTION

Television broadcasting services began in 1936 in England and France, and in 1939 in the United States, but the onset of World War II and the destruction of many European transmitting stations greatly retarded television's diffusion. When service resumed after the war, growth was fastest in the United States, where thirty-five million of an estimated forty-six million households had sets by 1955.[29] Only five countries had television service as late as 1950, though the number rose to seventeen in 1955 and sixty-eight in 1960. By 1980, 138 countries had television service, and it was estimated that some 400 million receivers were in use around the world.[30]

The Great International TV Standards Wars

In some ways, there were many national differences in radio broadcasting. The pre-war period had seen long-lasting and bitter squabbling, particularly in Europe, about frequency allocations for AM radio and there were many complaints about interference between stations in neighboring countries. Internationally, radio service varied widely in terms of program content. In a technical sense, however, AM radio systems were remarkably similar across the world. This was certainly true from the listener's point of view, since a single type of radio receiver could be used almost anywhere in the world with good results. Not so for television. Basic technical specifications for television varied considerably from system to system and did not eventually merge into a single global standard.[31]

The public debate over television standards focused on one important aspect of transmission, namely the number of lines of

Most early postwar television receivers were, like their pre-war predecessors, bulky devices with rather small picture tubes. Within a few years, however, manufacturers had reduced the size and cost of receivers and increased the maximum picture size to 21 inches or more. Photo courtesy of General Electric

horizontal resolution drawn on the television screen, though there were many other issues at stake. The technical situation at war's end was confused even within countries, and pre-war television systems were nearly all incompatible. The British operated with a 405-line standard, the French had 455 lines, the Germans 441, the Danish 567, and the United States 525.

When television broadcasts resumed after the war, only the U.S. standard remained unchallenged, and several countries adopted it (or the 625-line version adapted for areas with 50 Hz electric power). The British kept their pre-war standard for 405-line black and white for many years but would add 625-line black and white broadcasting in 1964. The French, who

Why Is There No Channel One in the United States?

Frequency allocations for television broadcasts have been changed several times since 1927, when the first experimental broadcasts were made. In 1928, the Federal Radio Commission established enough spectrum space to allow five channels of television, each 100 kHz wide, between 2 and 3 MHz. The allocations changed again in 1929 and 1937. Following the end of World War II, when networks were eager to make television broadcasting a regular service, the FCC once again redivided the spectrum, this time providing 13 television channels between 44 and 216 MHz, with a large section in the middle of this range devoted to FM radio, facsimile, and other services. The low end of the spectrum was occupied by commercial FM broadcasting services that would be reassigned to different channels, and the entire original FM allocation was eventually to be assigned to TV Channel One. Existing FM stations were given a deadline of January 1, 1948 to cease broadcasting in the old band. However, in 1948 the FCC decided to delete Channel One entirely and reassign it to other services, which was accomplished by 1952. By this time, television sales were taking off, so manufacturers were not asked to redesign their sets. Channel Two remained the lowest channel number.

had been compelled to use the German standard during the wartime occupation, now seemed more interested in devising their own high-definition black and white standard than in adopting any existing technology. In November 1948, Francois Mitterand, then Minister of Information, announced with great fanfare a new 819-line black and white system. Ironically, the French until 1956 also broadcast the pre-war German 441-line television, but only in Paris. By contrast, the Soviet Union and several other countries including Denmark, Germany, Switzerland, and Italy adopted the 625-line black and white system promoted heavily by the Philips company and RCA (and later the compatible 625-line color system). The eastern European nations with the exception of East Germany and Yugoslavia used still another black and white standard called System D.[32]

Though the ensuing standards negotiations may strike the reader as arcane, at the time they involved heady issues of national sovereignty. The understated BBC historian, Asa Briggs, commented there was "an element of drama in the European line struggle." Disagreement over these technical standards engaged world leaders as no technical standard had done before, reaching even Pope Pius XII, who let it be known that he was leaning toward the 819-line standard for proposed Vatican broadcasts.

First Regular Television Broadcasts in Selected Countries

Black and White Broadcasts

Germany	1935	Philippines	1953	Iran	1958
Great Britain	1936	Italy	1954	India	1959
Soviet Union	1938	Denmark	1954	Kuwait	1959
United States	1939	Thailand	1955	Lebanon	1959
Mexico	1950	East Germany	1955	Syria	1960
Holland	1951	Iraq	1956	UAR	1960
West Germany	1952	Australia	1956	Indonesia	1962
Canada	1952	South Korea	1956	Malaysia	1963
Japan	1953	Hong Kong	1957	Taiwan	1962
Belgium	1953	Saudi Arabia	1957	Pakistan	1964
Switzerland	1953	China	1958	Cambodia	1965

Color Broadcasts

Netherlands	1952	India	1959	Soviet Union	1967
United States	1953/4	Japan	1960	Western Europe	1967
Poland	1953	Ireland	1961		
Australia	1956	Canada	1965		

Standards issues were not simply technical questions, nor were their outcomes of interest only to the corporations making television equipment. Instead they reflected the political imperative to resist all sorts of foreign, particularly American, incursions into weakened postwar economies. It was evident to all involved that the American firm RCA, through its ally the Philips corporation, was busy at work attempting to promote an American-designed 625-line system in Europe. The television standards debate in France was particularly heated, reflecting the swell of French nationalism in the postwar period, and this partly explained why the French developed their own system rather than adopting one of the other standards.

Following the 1947 meeting of the International Telecommunications Union in Atlantic City, New Jersey, the ITU established a Radio Consultative Committee (CCIR) in 1948 with one of its aims being the standardizing of the standards, but it was only successful in codifying the existence of multiple standards and not reducing their number. The situation had not improved much by the late 1950s and early 1960s when European nations began to consider color television. After considerable debate, the countries of Europe chose between four different and mutually incompatible color standards, including the two that dominate today, which are known by the acronyms SECAM (Sequentiel Couleur Avec Memoire) and PAL (Phase Alternation Line). Eastern Europe including the Soviet Union (but not Yugoslavia or Romania), adopted the French SECAM system of color transmission after it was introduced in 1958. SECAM, first proposed by Henri de France of the Compagnie de Television, differed from others in that it transmitted its hue and saturation information sequentially rather than simultaneously. This necessitated an analog memory device in the receiver to store one line of information and store it until the rest of the information arrived to display the line in color on the screen.

The rest of Europe including Great Britain adopted the PAL system developed under the leadership of Walter Bruch of Telefunken in West Germany. Based on the NTSC system, PAL alternates the phase of the color signal from line to line to avoid certain types of distortion. Like SECAM, this system also required a one-line memory or delay unit installed in the receiver and line-identifying switching circuits. Meanwhile, partly through the efforts of the International Telecommunications Union, various black and white standards faded away until only four were left, and in 1985 the CCIR declared obsolete its standards for systems employing any other than 525 or 625 lines. This last item represented a hollow victory for the American companies that originally sponsored these standards, since by 1985 no American company made black and white television receivers or studio equipment.[33]

The existence of multiple standards had a bright side, which was that incompatibility helped to establish a minor industry in the manufacture of translating devices, so that programs could be exchanged internationally.[34] This type of exchange within Europe had been a serious problem until the CCIR helped establish a "Eurovision" network based on land transmission and converter stations, which simplified access to foreign broadcasts.[35]

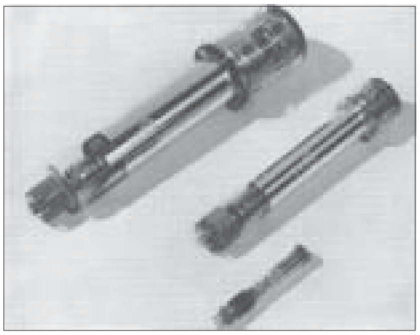
Television Standards in the U.S.: The Dispute over UHF

Television broadcasting and transmission standards in the United States were worked out before World War II by the NTSC, so that when postwar broadcasting resumed the situation had already stabilized to a certain degree. However, one standards-related issue decided after the war significantly affected the structure of American broadcasting for many years. This was the FCC's decision to continue to use frequencies in the VHF range for television in the postwar years, even though equipment to use the much wider UHF band was by then practical. It was not until 1953 that the UHF band was opened for regular broadcasting, but even after UHF stations were in operation, set manufacturers were not required to include a UHF tuner as part of television sets. UHF station owners complained loudly that their band had been given "second class" status in favor of the established VHF channels, and noted that many VHF stations were the ones affiliated with the major networks. It not until 1964 that set makers were required to include UHF tuners as part of new television receivers, but the new regulation still did not satisfy UHF interests. Station owners still complained that the odds of their success were threatened by FCC rules that allowed less-costly "variable" tuners (i.e. in the style of radio tuners rather than the more convenient pre-set tuners used for channels 2-13. The issue was never fully resolved, but became more or less irrelevant in the 1980s with the decline in the availability of mechanical tuners of any sort in favor of electronically tuned receivers and infrared remote controls.[36]

Changes in Broadcasting Technologies: The Legacy of World War II

Many circuits and devices developed for television in the 1930s found application in early radar systems, as when British radar researcher Eddie Bowen combined a CRT and a television receiver into a lightweight, experimental airborne radar system in 1937. A few years later, after World War II, the trend would be reversed as electronics manufacturers applied technology used for military applications to civilian television equipment.[37]

Philco, a major beneficiary of U.S. War Department contracts during World War II, used its new technological base to manufacture both consumer television receivers and equipment for microwave-based television transmission networks. The company demonstrated the system in April of 1945 by beaming program material from the Statler Hotel in



The Image Orthicon, a television camera tube, was widely used after World War II. Photo courtesy of General Electric

Washington, D.C. to a station in Philadelphia using a series of relay towers. Other radar manufacturers were working along the same lines. AT&T, RCA, Raytheon, and a joint venture between GE and IBM all announced similar microwave distribution networks shortly thereafter. In the end, AT&T's system would prevail.[38]

One of the key innovations in postwar television production was the Image Orthicon tube used in television cameras to substitute for an older pickup tube called the Iconoscope. Originating from a tube developed by Albert Rose and Harley Iams of RCA in 1939, the Orthicon was first used in experimental guided bombs code-named the Block Equipment. Like the Iconoscope, the Orthicon contained a photoemissive plate sensitive to light that retained a sort of electrostatic impression of a visible scene. Electrons from a beam scanning the plate would be absorbed or reflected according to the state of charge at a particular spot on the plate. Thus the reflected beam, which was detected as the signal, would be a "negative," version of the original image. Then it was relatively simple to create the "positive" signal electronically. After the war, Rose, Paul Weimer, and Harold Law developed a version that would be widely used for broadcasting, known as the Image Orthicon.[39]

Because the Image Orthicon was so much more sensitive than the Iconoscope, it was immediately picked up by postwar broadcasters for use in cameras. Its major flaw was the high inherent level of video "noise" that it generated. The Iconoscope, because of its high image quality, continued to be widely used for the conversion of films to broadcast. The Image Orthicon remained the standard for almost 20 years, and its nickname, the "immy," is the root of the "Emmy Award."[40] Marconi Communications Systems, an English company, was prominent in the field of television cameras from the 1950s on, using the Image Orthicon tube in cameras of its own design. While RCA was the major supplier in the U.S., Marconi soon came to dominate the European market.[41]

Transmitters and Transmission

The creation of new television networks worldwide created a market for new types of transmitting tubes, transmitter assemblies, and antennas. The Klystron tube, another product of wartime radar research, figured prominently in many postwar transmitter designs. Because of the high power requirements of broadcast transmitters (both radio and television), solid state components were slow to find their way into the market, and many stations today rely on vacuum tubes for the final amplification of their signals.

Just as in the early days of radio, television production was predominantly live. Much effort went into the development of transmission technology to allow the distribution of television programs instantaneously from a central point. For example, most television programming in the United States originated in New York, Chicago, or Los Angeles, yet there was initially no link between east and west. AT&T, however, quickly established television links using coaxial cable and the new technology of microwave transmission. Coaxial cable had already been in use for some years to provide multiplexed voice circuits for telephony and wideband program circuits for radio networks. The first inter-city "L1" coaxial cable link was installed between New York and Washington, D.C., using 3/8 inch diameter cable and special electronic repeaters. The bandwidth was only 2.7 MHz, so that only black and white images could be transmitted this way. New technologies to transmit color TV remained several years away. Microwave transmission, an outgrowth of radar work during World War II, was possible as early as 1951, with the first microwave relay link between Omaha, Nebraska, and San Francisco, California.[42]

National Differences in Television Broadcasting Techniques

Aside from the many well-known differences between American and European programming, there were significant technical differences as well. For example, in the Soviet Union, videotape recorders were less commonly used than elsewhere, while live broadcasting persisted longer than in the U.S. or Europe. The U.S., for many years the leading supplier of videotape equipment, put restrictions on the overseas sale of VTRs in the 1950s, and persuaded Japan to do the same, leading to a shortage in the U.S.S.R. The rationale for this was that videotape technology could be turned to military purposes. The Soviets designed and built much of their own television production equipment, however, and built an experimental video tape recorder in 1961, years after the first commercial VTRs were available in the U.S.[43]

European transmitter tower design also took a distinctive path in the postwar era. Whereas most U.S. towers were rather utilitarian, slender, triangulated-frame designs held up with guy wires, European towers were often self-supporting structures intended to be public attractions. A 1,750-foot television tower at the major Soviet TV production facility in Ostankino was claimed to be the tallest self-supporting structure in the world. Many European cities built centralized, multi-purpose telecommunications towers which loomed over the other architecture and which often housed public observation platforms and restaurants.[44]

Before the advent of videotape recording, most television originated from motion picture film. The television film "chain" shown here included a 16-mm projector and a Vidicon television camera. Photo courtesy of General Electric

Video Recording in the Television Studio

While certain widely appealing live shows thrived, justifying the cost of network transmission, television industry managers sought ways to reduce costs and increase efficiency (particularly by making it cheaper to repeat performances) through the use of recordings. The established technology of image storage, motion picture film, was initially the only technology available for television transmission. Films not only allowed networks to repeat performances at a lower cost, but allowed independent producers to syndicate programs and distribute them by courier or mail. Film was so important in television production that by 1960 over 80 percent of network programs originated from it. But film was unsuitable for certain types of programs, such as news, since it required time-consuming processing before it could be televised. Film stock was also expensive, and the amount of it needed to keep a television network or station running was almost prohibitive. Thus as recorded programming became an established part of television, the industry began to look for ways to lower its cost.[45]

Storage of television images through the mid-1950s was accomplished using 16-millimeter film and special film-to-television converters. The standards adopted for television in various nations in large part determined the type of converter used. In the U.S., television was broadcast at the rate of 30 frames per second, corresponding to one-half of the frequency of the electric power to which television equipment is synchronized. However, the worldwide standard for 16-millimeter film equipment was 24 frames per second. In Europe, where power frequency is 50 Hz and television operates at 25 frames per second, it was easy enough to speed up the film a little to achieve synchronization. This allowed them to use Flying Spot film scanners to convert film to television at a one-to-one frame rate. In the U.S., film scanners had to achieve a "3:2 pull down," a technique to convert six film frames to five television frames each sixth of a second. The equipment used in this conversion projected the film onto a television image tube rather than scanning the film directly as in the European case. An analogy would be that of an individual going to a movie theater with a camera in hand to obtain a copy of a film on the screen; the final image was somewhat degraded. More serious were the problems encountered in recording television images for later transmis-

Ampex employees demonstrate their new Videotape recorder about 1965. "Videotape," once an Ampex trademark, soon fell into common usage to describe all magnetic video tape recorders. Photo courtesy of Ampex Corporation

sion (as opposed to broadcasting directly from a film source such as a Hollywood movie). Here, the Kinescope method was used, which was simply the recording on film of the image from a television screen. Sound was provided by a magnetic tape recorder synchronized (either mechanically or electronically) to the film. On top of all its technical problems, the Kinescope method was expensive.[46]

Today, the most common way that broadcasters record video signals is by videotape recording. Research in video recording began in the late 1920s, and certain kinds of video information, such as radar "scope" signals, were recorded on magnetic tape during World War II, but the wide bandwidth required to record television proved to be a daunting obstacle. Several organizations independently began work on video tape recorders in the early 1950s: RCA, GE, Marconi in Britain, the Armour Research Foundation, and Bing Crosby's firm Bing Crosby Enterprises.[47]

RCA entered the magnetic recording field shortly after World War II, designing a line of wire and tape recorders for audio. By 1951, however, RCA turned to research on video recording, putting Harry Olson in charge of its team of engineers. At about the same time, at Bing Crosby Enterprises, audio engineer Jack Mullin also began working on a videotape recorder. The Armour Research Foundation's Marvin Camras also designed an experimental video recorder with a special rotating head design. While his recorder was not a success, the rotating head would be picked up by Ampex.

The first demonstrations of video recording equipment were disappointing to say the least. Late in 1951, Jack Mullin of Bing Crosby Enterprises demonstrated a crude video recorder to the press; in late 1953, RCA did the same. Elsewhere, Dumont, General Electric, the BBC, and magnetic recording pioneer Edward Shuller in Germany all worked on the problems associated with recording standard television signals on a magnetic tape. However, it was an upstart firm, Ampex Corporation of California, that succeeded in producing the first recorder with features acceptable to broadcasters. Ampex was a prototype of the "Silicon Valley" high technology firm, capitalizing on the resources provided by local colleges and the nearby motion picture industry. The Ampex Videotape recorder[48], demonstrated with great fanfare in 1956, recorded black and white signals onto two-inch-wide tape using the novel principle of helical scanning. In this method, four recording heads mounted 90 degrees apart in a rotating drum laid down the recorded track as a series of diagonal stripes across the width of the tape. This technique solved a vexing technical problem; engineers in the late 1940s believed that the bandwidth requirements of television would require impractical tape speeds of 4000 inches per second (versus audio tape's fifteen inches per second). Different inventors found ways to reduce the tape speed and RCA demonstrated a machine operating at only 120 inches per second, but tape consumption remained a critical problem. Not only was the wide, high-quality tape required for video expensive, but the mechanical devices needed to control a huge reel of tape were heavy, bulky, and unreliable. By reducing the speed to only thirty inches per second, the Ampex VTR made videotape recording much less expensive than film recording. Combined with the fact that the Videotape machine made instant records requiring no processing, and that tapes could be re-used if needed, magnetic recording was instantly attractive to a growing industry that consumed more feet of motion picture film per year than Hollywood studios. Ampex took orders for $5 million worth of these $50,000 machines at their first public demonstration, and grabbed a virtual monopoly of the market that lasted for several years.[49]

The Ampex tape recording system divided the incoming signal information into discrete intervals, each of which was short enough to be recorded across the width of a tape, perpendicular to its length. Such a system gave high-quality results, but the machines of the 1950s and 1960s were bulky and needed careful maintenance. Greater portability and ease of use came with the second generation of recorders, which used a "helical scan" process. Though the image quality of early helical scan recorders was not as good, gradually, helical scan VTRs were improved to the point where the image quality satisfied television broadcasters, and they became especially important in electronic news gathering.[50]

The Battle for Color TV in the U.S.

A new standards war, limited to the United States, developed as manufacturers forged ahead with plans for color television. Unlike the rhetoric surrounding the European battle, which concerned issues of national sovereignty, in this case the issue was that of modernity—specifically, RCA tried to convince the public that electronics was the essence of postwar modernity, as compared to mechanical technology, which was said to be a relic of the past. RCA and its competitor, CBS, were both major corporations with deeply entrenched commitments to their own particular technical standards. CBS in the past had been only a broadcasting company, but was moving into the realm of electronics research and had entered the manufacturing field through the acquisition of the Hytron Radio and Electronics Corporation of New York.[51] RCA was the largest manufacturer of home television receivers, and also made a full line of television transmitters and studio production equipment.

The FCC in 1945 had deferred a decision about color standards, then chose the CBS standard in 1950 on the basis of successful demonstrations. The CBS system, developed by Austrian immigrant Peter Goldmark, used a rotating "color wheel" filter to generate separate red, green, and blue images, which were transmitted in sequence and recombined by the receiver, again using a mechanical color wheel, to form a full-color image. The only mechanical element of the system was the rotating wheel, and the rest employed ordinary electronic television technology, but RCA leaders attacked these mechanical features, proclaiming that they were a throwback rather than a leap forward.

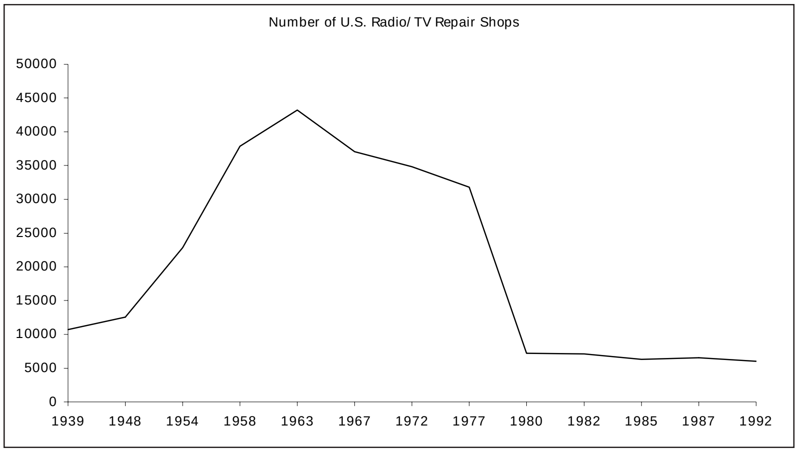
A ban on color TV receiver production during the Korean war gave RCA the time it needed to perfect its own system of all-electronic color television. In this system, the color information or "chrominance" signal was transmitted separately from the "luminance," or total brightness signal. An ordinary black and white receiver had only to receive and display the latter, thus making the RCA color transmissions compatible with existing black and white televisions. After an intense publicity campaign and much behind-the-scenes maneuvering, the FCC finally reversed its endorsement of the CBS system in 1953 and allowed RCA to move ahead with all-electronic color. But sales of color televisions did not approach those of black and white sets until the late 1960s, and it was not until 1972 that more than half of American households with televisions had a color set. By 1975, however, approximately 46-million households had a color receiver.[52]

New Receiver Technologies

The heart of the television receiver is its picture tube. Monochrome picture tubes were developed for use in oscilloscopes and were widely used as early as the 1930s. Postwar television production made numerous improvements to the picture tube, making it less prone to implosion, less expensive, larger, flatter, and more rectangular in shape (to fit the shape of the source material, which was often film). Tube sizes were generally seven inches or less in 1947, but by 1949 manufacturers such as Dumont began offering ten-inch or larger tubes.[53]

The color Kinescope was developed in a remarkably short time by engineers at the Radio Corporation of America. Color Kinescopes, then and now, use the shadow mask principle, in which the three streams of electrons (representing the red, green, and blue beams) are aimed at the phosphor-coated screen through a very fine mesh. The beams are aimed

Number of Television Repair Businesses in the U.S., 1939-1992



so that they strike the appropriate red-, green-, or blue-emissive phosphor dots, which are placed in groups of three; when viewed, these combine to form a picture element, or pixel. This principle was first proposed in 1938 by Werner Flechsig in a German patent, but was not applied commercially until RCA's first shadow mask tube in 1949. An important advance in color tubes was Sony's 1968 development of the Trinitron. This tube utilized a line-type mask and phosphor pattern and an improved, common focus electrode which allowed for a smaller beam spot size.[54]

While most television receivers still use cathode-ray screens, by the 1970s and 1980s vacuum tube-based cameras were beginning to be challenged by new solid state designs. The primary motivation in this was the desire to make electronic news gathering easier through the miniaturization of equipment. Again, RCA led the way, by developing a solid state CCD element to convert the visual image to an electrical signal, plus the increasing use of integrated circuits in place of vacuum tubes and transistors. However, RCA's success was only momentary, as competitors in Japan and Europe moved into the market. By the 1980s, solid state imaging devices found considerable commercial success in consumer "cam-corders" and surveillance cameras.[55]

Television Receiver Production

A television purchase was a big investment in the postwar years. Prices for receivers started at about $200 for the least expensive sets and were more like $400-500 for the larger, "living room" sets. In addition to the purchase price, sets had to be installed at additional cost and an antenna set up, usually on the roof of one's home. Early televisions, like all vacuum tube electronics, also needed regular maintenance. With more than three times the number of tubes than a standard radio, the early sets represented a considerable maintenance expense. Television production methods and electronic components changed considerably beginning in the 1950s, however. Television makers made extensive use of printed circuit boards and automated assembly techniques, reducing the cost of TV sets by nearly 50 per cent by the early 1950s. Most manufacturers were slow to adopt the new transistor technology, however, and it was a Japanese company, Sony, that introduced the first transistorized television, the model TV8-301 in 1960.[56]

Broadcast receiver technology of the postwar period changed continually, as did the conditions under which it was made. In the United States, companies that made radio receivers saw their share of the market drop from about 99.9 percent in 1955 to about 16 percent in 1980. Exports of receivers actually rose, but almost all of these were specialized, high- priced units. The average value of imported receivers in the early 1980s was under $200, as compared to over $700 for U.S.-made exports. Certain other consumer electronics markets in the U.S. saw this takeover by imports, mostly Japanese firms, at an even earlier time. The date at which imports took 90 percent of the market for tape recorders was 1968; for radios, 1970. Half of all black and white television receivers, phonographs, and radio-phonograph combinations were imports by 1970. By the early 1970s, virtually the only remaining markets for U.S.-made consumer electronics products were automobile radios and color television sets. American manufacturers of color television sets managed to maintain about 80 percent of the market until the 1980s, though the number of firms dropped from eighteen in 1968 to six in 1980. It is also worth noting that the market for television receivers remained sizable during these years. Manufacturers sold more than $6.5 billion worth of color television sets in 1996, plus over $2 billion worth of black and white, projection, and combination TV/VCR units.[57]

A variety of television cameras employing the Image Orthicon tube, circa 1960. Photo courtesy of General Electric

Technological Alternatives to the Networks: Subscription and Cable Television

The idea of selling television service to consumers instead of financing it through advertising or government subsidies originated in the earliest days of broadcasting. Zenith Radio Corporation, an early television broadcaster, had introduced its Phonevision system in 1931, a technology using modified telephone lines to deliver electronically "scrambled" television signals to homes. A set-top box corrected the signal if an appropriate punched card were inserted into the box. After World War II ended, Zenith and RKO (a subsidiary of RCA) invested $10 million in a pay-TV system to serve the town of Hartford, Connecticut. The system provided ordinary broadcast channels by wire during the day, and special "pay per view" features in the evenings.[58] By the 1960s, a Canadian service was supplying pay television programming using equipment made by the International Telemeter Corporation.

Until 1977, the FCC tightly regulated cable television, resulting in slow growth. Much of its early growth was in the suburbs, areas not well served by broadcast stations but densely populated enough to justify the major expense of infrastructure building.[59] In 1952, the first year for which statistics are available, there were only 14,000 subscribers to cable systems in the U.S. The number had risen to over 26 million by 1983.[60]

Cable television broadcasters benefited enormously from the introduction of satellite transmission systems. Previously, these systems had exchanged programs with other broadcasters by exchanging video tapes or films via a "bicycle" network (so named because of a few instances of material actually traveling via bicycle). In 1975, Home Box Office became the first pay cable network to use direct transmission by satellite. A little later, WTBS, a small UHF station in Atlanta, Georgia, began distributing its regular programming (consisting of movies, re-runs of older television shows, and advertisements) to other cable systems via satellite. The station charged participating cable operators about five cents per subscriber per month to re-broadcast WTBS. Within two years of their inauguration, both Home Box Office and WTBS were financial successes and both drew a host of imitators.[61] Cable television has not been a worldwide success. Rather, it is a way that a few wealthy countries have provided premium television services in addition to standard broadcasts.[62]

Another Alternative: Direct Satellite Television

The preeminent use for artificial satellites has been for telecommunications, often civilian rather than military. The first Russian Sputniks, launched in 1957, were in fact telecommunications satellites. However, most satellites were used only for narrow-bandwidth voice transmissions through the 1960s, when integrated circuits and other innovations began to make satellite television less expensive.[63]

Postwar telecommunications in the Third World, particularly telephone service, was dominated by the role of satellites in the postwar period. The original purpose of satellites was to link continents, and organizations such as INTELSAT initially concentrated on this business. But soon, developing countries trying to "catch up" without the huge cost of coaxial or microwave distribution networks began to think of satellites in terms of domestic service. INTELSAT first experimented with this kind of service in 1972, when TV programs originating in Alaska were broad-

High Definition and Digital Television

Even in 1945, when television broadcasting had just begun, engineers argued the relative merits of improving the quality of TV images. The French, for example, chose a standard with 819 lines of horizontal resolution versus the U.S. standard of 525 lines. Several different proposals for high definition color television emerged between 1950 and the 1990s, but all were rejected on the grounds that they required too much bandwidth or would make receivers too expensive for consumers to afford.

Digital television experiments began in earnest in the early 1970s, when the BBC, Ampex Corporation, and others began to develop digital video tape recorders. Ampex was apparently the first to demonstrate a commercial system in 1979. By this time, however, video editing machines had already been partially converted to digital operation, and the basics of digital television imaging were in place. Although digital television promised interference-free reception, it required even more bandwidth than standard analog broadcasting.

The Japanese were innovators in HDTV, broadcasting it experimentally in 1981. However, the 30 megahertz bandwidth required for one channel of the Japanese HDTV system used all the available broadcast channels. Engineers developed a new data compression algorithm called MUSE (which stands for multiple sub-Nyquist encoding) in 1985, allowing digital signal compression, although transmission of the signal was still analog. In combination with Direct Satellite Broadcasting, HDTV became a popular service in Japan, even though an HDTV broadcast still required the equivalent bandwidth of two NTSC channels and was subject to interference and other distortion.

The possible export of Japanese HDTV to the United States became the focus of a hotly debated political issue in the U.S. in the late 1980s. The humiliating collapse of the U.S. consumer electronics industry in the 1960s and 1970s led Congress to sponsor a movement to create an American version of HDTV. By doing so, they believed that the U.S. could take the lead in establishing a new consumer television manufacturing industry. By 1987 the FCC had organized a committee to study HDTV standards, but the agency made little headway for several years. A particular concern was rapid change in digital electronics technology, which soon made all analog HDTV proposals seem obsolete. The FCC in 1990 made the decision to allow a new HDTV service that is not compatible with existing televisions, shattering a long tradition of insistence on "backward compatibility" for new services. At about the same time, most of the companies and research laboratories experimenting with HDTV were switching from analog to digital systems, in recognition of the rapid advances in digital signal processing and VLSI chips. Finally, in 1993, a consortium of U.S. manufacturers, laboratories, and others with a stake in HDTV (including AT&T, General Instruments, MIT, Philips, Sarnoff Laboratories, Thomson, and Zenith) formed a new "Grand Alliance." The first experimental HDTV broadcasts in the United States began in 1994, supplied by satellite to consumers who purchased special receiving antennas. By 1995, the FCC had approved a set of standards, and thus the technical component of commercial HDTV was in place. Broadcasters have been authorized to begin implementing HDTV over the next few years, but it remains to be seen whether this new service will succeed.

cast within that state via a satellite over the Pacific ocean. This service went commercial in 1975, with some nations using it mainly for telephone service and others setting up national TV networks almost instantly. The former USSR and Canada operate several of their own domestic satellites, or "domsats," providing telephone and television.[64]

Like many countries, Japan's mountainous terrain makes it difficult to reach all television viewers using conventional broadcasting methods. The Japanese were leaders in supplying consumers with cable television, but by the 1980s had shifted the focus to satellite transmission. Whereas American consumers in rural areas often purchased 1.5-meter satellite receiving dishes, these dishes were far too large for the cramped Japanese urban conditions. Japan's 1987 Direct Broadcast Satellite (DBS) was the first in the world, and attracted over one million customers within a year. The higher power DBS system allowed for much smaller 75-cm dishes, which made urban reception feasible.

Satellite TV and DBS in the U.S.

Cable television networks in the United States owed much of their success not to the land-based transmission technology of coaxial cable but to the national or international distribution of programs via geosynchronous satellites. The FCC in 1972 decreed that virtually any legitimate entity could own and operate a space satellite, creating an "open skies" policy in which AT&T was actually restrained from adding to its fleet of satellites for a period of years. Immediately RCA, Western Union, and several others took advantage of the opportunity. RCA, for example, had its first satellites in operation by 1975/76, finding customers in the Department of Defense and the Armed Forces Radio Service, the Alaskan telephone and television service, and two cable networks. Programs originating from a variety of sources were beamed to these satellites, shifted in frequency to avoid interference, then rebroadcast to earth, usually in a wide pattern. Despite the fact that the power of this "transponder" was only 5 or 10 watts compared to the hundreds of thousands of watts typical of many television stations, the placement of the satellite allowed the signal to reach a huge geographical area.

In North America and Japan, a portion of the spectrum in the K-band (12 and 14 GHz) was set aside for direct-to-home broadcasting. While the K-band did not interfere with terrestrial microwave telecommunications systems, as earlier satellite systems did, it was affected by atmospheric conditions such as rain. These K-band DBS systems used somewhat less bandwidth, more power, and required much smaller receiving antennas. They were intended to compete with cable systems or provide cable-like service in rural areas.

THE ECONOMIC AND SOCIAL ASPECTS OF TELEVISION

Hollywood and Television

One of the chief economic effects of television's success was to throw the motion picture industry into turmoil. The postwar period saw rapid changes in the technology of making motion pictures and the ways that people saw the movies. Television and rapid suburbanization contributed to declining attendance at urban movie palaces, as annual movie admissions in the U.S. dropped by a factor of six between 1948 and 1967. As these theaters began to close during the 1950s and 1960s they were replaced by drive-ins and less grandiose theaters in suburban shopping malls. Television viewing, which in the 1940s was expected to decline after the "novelty factor" wore off, continued to rise, from about six hours per day in the U.S. in the 1960s, to about seven hours in the 1970s, and finally to eight hours in the late 1980s.[65]

Motion picture exhibitors (i.e. theater owners), hoped to contain television in its early years by installing projection television equipment in theaters and arranging for special broadcasts. Excluded from direct ownership of television stations by postwar antitrust legislation, the motion picture industry turned to the promotion of television viewing in theaters. Of the many projection television systems demonstrated in the laboratory, only a few actually saw commercial use, including the RCA system for relatively small theaters. A competing system promoted by Paramount actually recorded television signals (received via a land line feed or over the air) onto a special 35-millimeter film, processing the film almost instantly and projecting it in the conventional way. While Paramount in particular hoped to revitalize interest in live theater through the use of live television, the motion picture producers found that only sports events could draw people into the movie houses to watch television. Television-equipped theaters were never common, numbering only 75 in the United States in 1950, and the cost of the necessary equipment was a daunting obstacle to their diffusion. By 1953, when motion picture producers began experimenting with three-dimensional movies and wide- screen formats, experiments with theater television declined, not to be seriously attempted again until the 1980s, when satellite television networks briefly revived the idea of showing live sports events in theaters.[66]

As theater attendance in the U.S. dropped by 50 percent between 1946 and 1952, Hollywood imposed austerity measures, including the reduction of stars on its payrolls and experimentation with new technologies. Some of this experimentation was intended to cut the cost of production, as in the use of magnetic sound recording for production purposes. Much of it, however, was intended to make films more appealing to the public.

Always striving for greater "realism" in film, Hollywood movies in color began to appear in greater number after the early 1950s, though the color process had been available since the 1930s. Beginning in the early 1950s, Hollywood began to produce movies designed to use special types of projection. The first of these was the stereoscopic, or three-dimensional, film. By using two cameras, separated by the approximate distance between the eyes, projecting both of these images onto the theater screen, and then providing the viewer with special polarizing glasses, producers achieved a startling “3-D” effect. Two slightly different processes, both demonstrated as early as the 1920s, were used for color and black and white films. In the former, the projectors included special filters to polarize the light corresponding to each image in two different directions, the polarized lenses of the viewing glasses allowing the viewer’s brain to separate the images. A 3-D movie fad ensued, but fizzled after the novelty wore off in the mid-1950s, only to be revived several times in later years, particularly for horror, science fiction, and pornographic genres. 3-D movies and television shows still occasionally appear, almost always using the color process. Film makers in the Soviet Union, France, Spain, and elsewhere used variations of the stereoscopic process to make films, devising about a dozen variations of the technology.[67]

Another exhibition technique of the era involved at least a half-dozen variations on the theme of wide-screen projection. The standard aspect ratio of theater screens since the 1920s had been approximately 1 to 1.5. Although wide-screen formats had appeared in the 1930s, another round of experimentation appeared after World War II. The most dramatic was inventor Hazard Reeves’ Cinerama. Using three cameras, Cinerama covered approximately 146 degrees of panorama on a wide, curved screen. The system incorporated multichannel stereo, a higher-than-usual frame rate, and demanded special modifications to theaters. Cinerama was expensive both to shoot and to exhibit, and after a few notable films, such as *How the West Was Won* in 1962 and *The Wonderful World of the Brothers Grimm* in 1963, enthusiasm faded. Cinerama’s sponsors and several others subsequently shot many films on the less expensive double-width 70-millimeter film, or used 35-millimeter film with special lenses to produce interesting but somewhat less spectacular wide-screen effects under the names CinemaScope, Superscope, Todd-AO, Super Panavision, and others.[68]

Motion picture production and exhibition since World War II has seen a great shift toward the use of electronics technologies. In exhibition, the use of control information on the film, sometimes in digital form, has been used in several different special sound systems, notably the Dolby Laboratories stereo system and Sensurround, another multichannel system. Motion picture producers have used digital electronics to enhance special effects on film. The popular appreciation of this technology came with the release of the Walt Disney film *Tron* in the early 1980s.

The Critique of the Mass Media

The rapid expansion of electronic communications after World War II prompted renewed efforts by scholars to assess their “impact” on society. Earlier in the century, scholars had seen mass media as either vehicles for social good or evil—or sometimes both.[69] Progressives sought media reform because they believed that the mass media had superseded personal communication in industrialized societies. Therefore, the media might rectify or aggravate social problems associated with industrialization, such as the loss of a sense of community, and the decline of political participation. Among this movement’s early leaders was the pragmatist philosopher John Dewey, who in 1916 began publishing studies of the uses of media. He felt that internationalism and industrialism had replaced local autonomy and that communication was a potential tool for creating an environment in which local communities kept elites and scientists aware of their local problems. Democracy required this sort of “unshackled media” to keep citizens fully informed.[70]

Beginning in the 1930s, German immigrant Paul Lazarsfeld began the first of a highly influential series of studies on media effects that would influence the field for many decades. Lazarsfeld postulated that the media reaches “opinion leaders,” who in turn pass on their opinions to the less interested.[71] A second line of inquiry that would become very important in the postwar period originated among a group of scholars who left Germany during the 1930s and who re-established themselves at the University of Chicago. This “Frankfurt School” rejected the quantitative methodologies of Lazarsfeld and attempted to explain the nature of mass media through an understanding of the commercial structure and ideological basis of the media “industries.” Much of the work of the Frankfurt School became known only after 1945, and provided part of the intellectual basis for the countercultural movement of the 1950s and 1960s. One of the most famous of the Frankfurt School scholars, Herbert Marcuse, argued that industrialization and modern media encouraged a “one-dimensional” existence without real social discourse. The writings of Canadian scholars Harold Innes and Marshall McLuhan drew upon Frankfurt School ideas about the hierarchical structure of the media and its implications. McLuhan seemed less disturbed by this condition, and went so far as to say that the worldwide interconnection of communities through electrical communication would create a happy sort of “global village.”[72]

Meanwhile, Lazarsfeld’s concept of “limited effects” became nearly universally accepted by the 1960s.[73] Even media corporations themselves adopted this model. In 1960, J.T. Klapper, head of research for CBS, published *The Effects of Mass Communications*, which elaborated the “limited effects” theory. Television networks, under attack because of their heavy use of advertising, found comfort in the limited effects theory, because it meant that they could not be directly blamed for society's evils. On the other hand, the notion that the messages in television advertising had only limited powers of persuasion obviously undermined the medium's commercial basis. Nonetheless, taking a middle ground seemed preferable to either extreme.

As television continued to make inroads into American life (Americans watched an average of 5.1 hours per day in 1960[74]), the limited effects consensus and the presumption that the media had mostly benign effects once again came under fire. By 1961, 89 percent of U.S. households had a television set (the figure was 97 percent by 1976). While the content of radio had been debated periodically since the 1920s, television seemed to elevate the public's concern over the supposed effects of certain types of programs on the public, and particularly on children.[75]

In 1952 and again in 1954, Senator Estes Kefauver organized hearings on the subject of juvenile delinquency, which paid careful attention to the content of television programs. At about the same time, a major project conducted in Great Britain by the Nuffield Foundation also studied the effects of television on children. The results, published in 1958, showed that children follow their parents' viewing habits and that more intelligent children watched less TV. Further, while researchers concluded that emotionally disturbed children may be driven to violence by viewing violence on TV, overall there was no discernible difference between viewers and non-viewers. This seemed to confirm the "limited effects" theory.[76] Other research seemed to indicate otherwise. The 1972 Surgeon General's Scientific Advisory Committee on Television and Social Behavior supported the idea that media violence increases likelihood of aggressive behavior.[77]

Research on sexual content in the media had similar results. In 1968, Lyndon Johnson appointed a Commission on Obscenity and Pornography, which published findings that did not show a strong correlation between obscenity and deviance. But the commission included Klapper of CBS, and some suggested that the media corporations were orchestrating the research.[78] This feeling seemed to be confirmed by Lazarsfeld who, late in his career, was said to have admitted that he felt a strong need to avoid losing the support of media companies, and that this may have affected his research.

The question of television's effects on viewers came to a head during the 1977 trial of fifteen-year-old Ronald Zamorra, accused of killing eighty-two year old Elinor Haggert. His defense was temporary insanity brought on by constant exposure to televised violence. Zamorra idolized the television detective Kojak, played by actor Telly Savales. That Zamorra was convicted seemed to indicate that the public (or at least the judge in the case) was not yet ready to accept the notion that television is a strong influence on behavior.[79]